

5 Implementation and Evaluation Plan

Establishing and implementing a successful Natural Resources Management Program (NRM Program) requires careful planning, sufficient funding, adequate staffing, and ongoing review and evaluation of program successes and failures. This section outlines the nuts and bolts of developing the NRM Program for the UH Management Areas on Mauna Kea and for implementing the management actions developed in Section 4. It also provides a methodology for evaluating the success of the program and for determining any need for changes in management strategies.

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5.1.1 Programmatic Management Actions

Most of the goals, objectives, and actions of the NRM Program are presented in the component plans in Section 4. However, there are several management actions at the programmatic level that apply to either the overall NRM Program or that should be completed prior to enacting the actions in the various component plans. These programmatic management actions include:

1. Complete formal adoption of the NRMP by the University of Hawai‘i. Initial implementation of the plan components can be undertaken by existing OMKM staff while the funding and staffing activities are in progress.
2. Establish a Natural Resources Management Program within the Office of Mauna Kea Management (OMKM).
 - a. Obtain sufficient funding to support the program (see Section 5.1.4).
 - b. Hire staff members. Although many of the management activities can be conducted with the aid of volunteers or in collaboration with other land management agencies, the minimum staffing needs for this program are one full-time Natural Resources Coordinator (NRC) and one or two full time field biologists. Support and administrative staff, such as secretaries and librarians, are already available at OMKM (see Section 5.1.2.1).
 - c. Contract out high-priority, field-intensive projects such as baseline inventory studies, to ensure they are conducted quickly (see Section 4.1).
3. Continue and increase the role of the Mauna Kea Management Board (MKMB) Environment Committee in the NRM Program.

The establishment of the MKMB and its associated committees has enabled the broader community to become directly involved in advising on the management of Mauna Kea. The committees have been useful in involving a range of interests to ensure a collaborative and informed management planning process. Each of the committees has its own mission, but there are few guidelines for how decisions are made, especially if there is no consensus or if the requisite expertise is not present. For example, the MKMB Environment Committee might more efficiently make defensible decisions if they had a protocol for evaluating the potential environmental impacts of proposed activities. The following activities are recommended to increase the decision-making power and participation in the NRM Program by the MKMB Environment Committee.

- a. Review and approve (or request revisions to) management decisions, plans, and reports made by the NRC (via semi-annual meetings and as needed).

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- i. Participate in annual and five-year reviews and revisions of Natural Resources Management Plan (NRMP). See Section 5.2.
 - b. Review and approve or reject (with input from NRC and expert advice, as needed) research proposals from outside persons or agencies.
 - c. Interact with other boards and committees (with participation of the NRC) to achieve agreement on management goals, objectives, and activities.¹
 - d. Incorporate decisions from cross-board meetings into the NRMP (during revisions), and into daily activities conducted by the NRC. The NRC should keep detailed notes of decisions made during these board meetings for use during revision process, as it may be a year or more until the next NRMP revision cycle begins.
4. Continue to include the other advisory committees as integral parts of the NRM Program. The following committees and councils should meet annually (and as needed) with the NRC and the MKMB Environment Committee, to discuss natural resource management issues and strategies, including potential compatibility and conflicts with cultural issues:
 - a. Wēkiu Bug Committee
 - b. Kahu Kū Mauna
5. Continue to develop working relationships with federal and state agencies.

Currently there is no mechanism for integrated or coordinated management of Mauna Kea's natural resources (including lands outside of the UH Management Areas). No regular meetings are held between the governmental agencies with management responsibilities for Mauna Kea—in particular involving OMKM and the various divisions of DLNR. Significantly, because there is so little interaction between the various state and federal agencies responsible for the management of Mauna Kea, applicable rules and regulations in the UH Management Areas are little enforced. Development of coordinated management between state and federal agencies and OMKM is discussed in Section 5.1.3.

6. To increase community involvement in decision-making processes, conduct public outreach and education.

Encourage and seek out community participation, including Native Hawaiians, in educational and outreach efforts. Education and outreach activities are discussed further in Section 4.4. Education and outreach relating to natural resources will be conducted or overseen by the NRC, with input from the OMKM director and MKMB Environment Committee.²
7. Establish legal authority for OMKM to promulgate rules and enforce regulations on Mauna Kea properties leased by the University of Hawai'i.³

¹ As the advisory board for OMKM, the MKMB has responsibility for making final recommendations, based on input from committees including Kahu Kū Mauna and the MKMB Environment Committee. Potential conflicts between interests must be considered as this is done.

² The NRC will work closely with an education and outreach coordinator when this position is filled.

³ Although it is desirable that this action be completed prior to establishing the NRM Program, it is not a requirement. There are many management activities and projects that do not require regulatory authority, including baseline inventory, monitoring, research, education, and information management. Aspects of natural resources management that require regulatory authority are managing access, providing rangers with the authority to enforce laws, and establishing fines for rule-breaking. It is recommended that obtaining rule-making authority be completed concurrently with the establishment of the NRM Program, and that the program operate regardless of OMKM's ability to enforce regulations (see Section 1.4.2.3).

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8. Manage access to the summit to reduce impacts to natural resources. Unrestricted access to the summit region can negatively impact resources. See Sections 3 and 4.2 for more information on the potential impacts of human use. Strategies for access management are presented in Sections 4.2 and 4.4.
9. Provide that the MKMB Environment Committee will have an active role in advising MKMB and OMKM with regard to natural resources when considering proposed future land uses (see Section 3.1.1.4) and ensuring the compatibility with recommendations in approved management plans, with the goal of protecting natural resources.

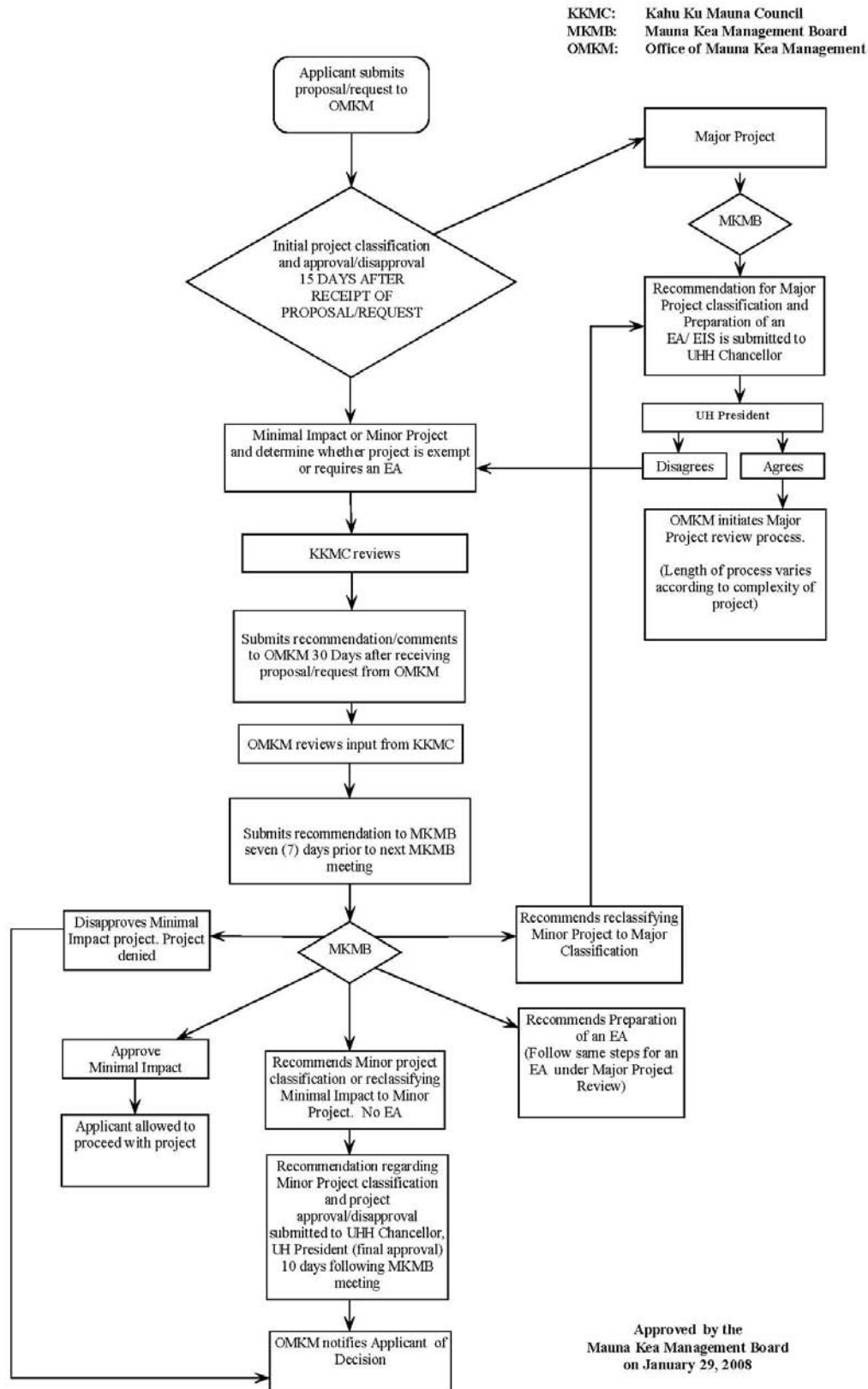
Although the UH Board of Regents and the President retain project approval and design review authority over all major developments within the UH Management Areas on Mauna Kea, OMKM, MKMB, and Kahu Kū Mauna are also charged with reviewing projects to ensure that they conform to the standards and guidelines set forth in the 2000 Master Plan. The 2000 Master Plan established a set of guidelines for project review and design, to ensure that proposed projects conform to and implement the concepts, themes, development standards and guidelines set forth in the plan (see Section XI, (Group 70 International 2000)). A Design Review Committee was established to interpret the guidelines and to ensure that proposed projects conform to the goals and objectives of the 2000 Master Plan and are consistent with the design guidelines.

The review process requires OMKM to work with other entities, including IfA, the University system, and DLNR. In addition to complying with federal, state and county rules and regulations, project proposers must be informed of additional conditions that OMKM may require. There is also a need, during the project design review process, for OMKM to provide clear facility planning guidelines to project proposers that address siting and design considerations, and to enforce them, so that proposed facilities result in minimal impacts to cultural and natural resources and the astronomical qualities of the MKSR. Many of these considerations have been developed in the 2000 Master Plan, and the MKMB Environment Committee should provide feedback and guidance on issues related to natural resources.

As specified in the 2000 Master Plan, each redevelopment or proposed new facility, including non-astronomy facilities, will undergo individual project reviews, that will include an environmental analysis pursuant to Chapter 343, Hawai'i Revised Statutes and a comprehensive analysis of the potential cultural impact. In general, the review process is applicable to any project involving any construction, installation or alteration upon any site, roadway, utility line, building, or other type of structure; any excavation, filling or change to surface topography; and any planting or removal of vegetation at a site that may be undertaken in association with these procedures (Group 70 International 2000). The 2000 Master Plan is somewhat vague on the definition of minor and major projects and leaves to the President of the University the final determination how the project would be classified. However, the operating definition considers construction activities – including excavation or the construction of new buildings – to be “major projects”, while “minor projects” are those such as building small structures (e.g., weather tower) on a previously modified surface, or an emergency staircase. The 2000 Master Plan established separate review processes for minor and major projects. Minor project review ends with the UH President, while major projects require formal approval by the UH Board of Regents. OMKM functions as a liaison to ensure consistency in the project review process and that the required entities engage in the process. A schedule for processing proposals submitted to OMKM was approved in January 2008 (see Figure 5-1).

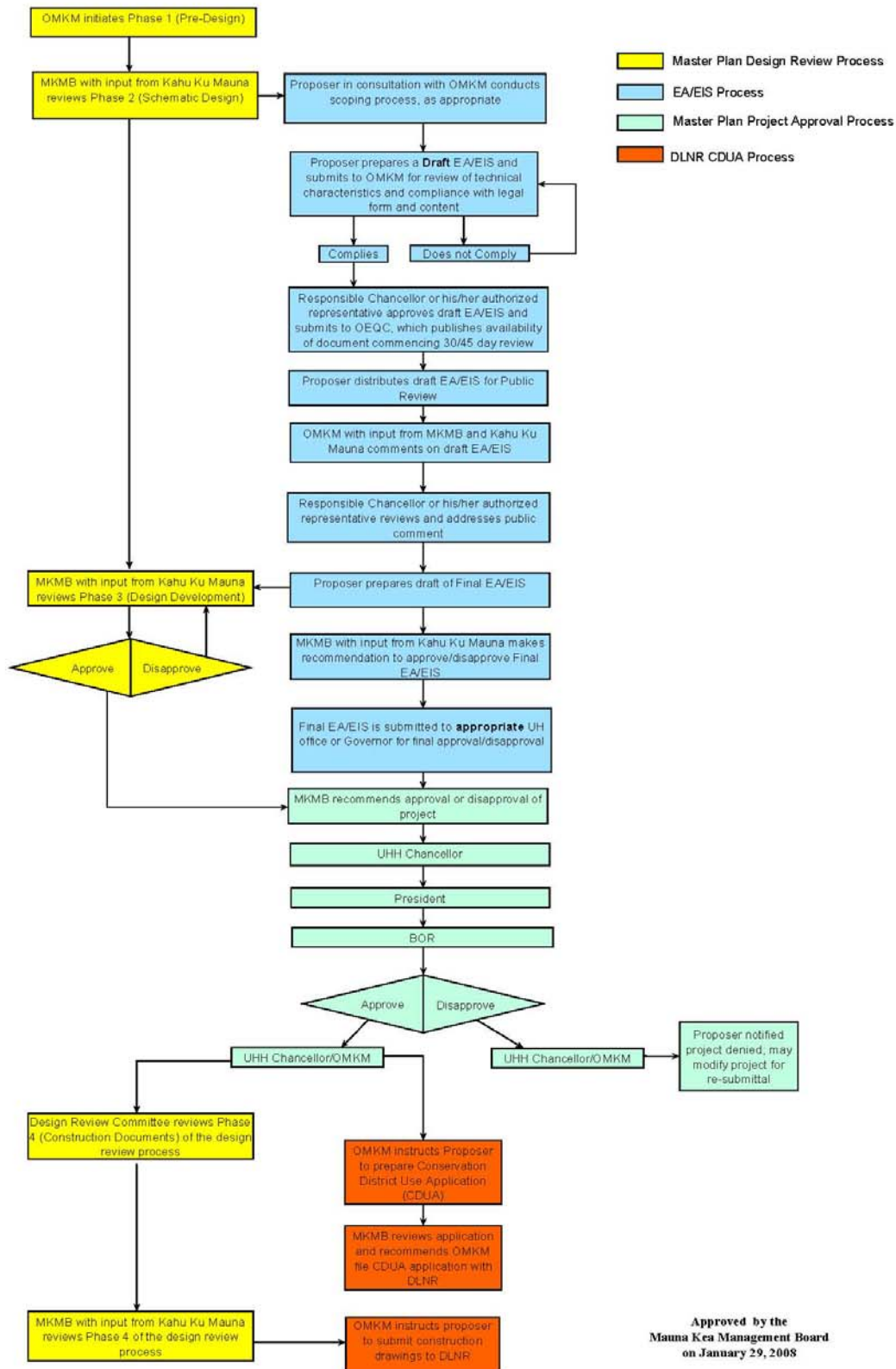
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Figure 5-1. Schedule for Processing Proposals Submitted to OMKM



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Figure 5-2. Major Project Review Steps



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In January 2008, the MKMB approved “Major Project Design Review Steps” (see Figure 5-2). This flow chart details the Master Plan Design Review Process, EA/EIS Process, Master Plan Project Approval Process, and DLNR CDUA Process. Included in the overall design review process is the need to conduct required environmental analyses, such as an environmental assessment or environmental impact statement, for future proposed actions. As an advisory body to the MKMB, the Environment Committee plays a role in the project review process, especially with evaluating the potential impacts on natural resources.

5.1.2 Personnel, Training, Equipment, and Facilities

5.1.2.1 Staffing Requirements

Table 5-1 details the staffing requirements for oversight of the NRM Program and implementation of the NRMP. Most of the positions are existing, funded OMKM positions or volunteer boards or committees. A minimum of two new full-time OMKM positions are recommended for developing the NRM Program: a Natural Resources Coordinator and at least one field biologist.⁴ The number of field biologists needed will depend in part on what proportion of the natural resources management actions is conducted in house by OMKM and what proportion is conducted by paid contractors (i.e., subject matter specialists, environmental consultants, Bishop Museum scientists, University of Hawai‘i faculty, and graduate students) and volunteer groups. As of the first draft of this NRMP, there are no dedicated natural resources management personnel within OMKM—all natural resources management activities are currently conducted by contractors advised by the MKMB Environment Committee.

Table 5-1. Staff Requirements

Position	Role	Current Status	Location	Funding Status
OMKM Director	Oversight, guidance	Exists and filled (Interim director)	OMKM Hilo	Currently funded
OMKM Associate Director	Oversight, guidance	Exists and vacant	OMKM Hilo	Currently funded
Mauna Kea Management Board	Oversight, guidance	Exists and filled ⁵	Various (meets at OMKM Hilo)	Unfunded volunteers
MKMB Environmental Committee	Oversight, guidance	Exists and filled ⁵	Various (meets at OMKM Hilo)	Unfunded volunteers
Kahu Kū Mauna	Cultural guidance on NRMP issues	Exists and filled ⁵	Various (meets at OMKM Hilo)	Unfunded volunteers
Natural Resources Coordinator	Implementation of NRMP	Position does not yet exist	OMKM Hilo/VIS	Requires funding
Natural resources field biologist(s)	Implementation of NRMP	Position does not yet exist	OMKM Hilo/VIS	Requires funding
Natural resources volunteers	Implementation of NRMP ⁶	Needed	Various	Unfunded volunteers, but requires oversight by NRC, field biologist, or rangers.

⁴ It is recommended that hydrological and geological studies be conducted by subject matter experts under contract.

⁵ See Section 1.4.2.1 for more information on the MKMB and its associated committees, OMKM staff (director, administrators, librarian), rangers, Mauna Kea Support Services (MKSS), and Visitor Information Station (VIS) staff.

⁶ Management actions conducted by volunteers could include invasive plant removal (weeding), establishing native gardens and maintaining them, education and outreach (on the mountain and at schools), plant and animal surveys (by qualified individuals), trail maintenance, and trash and debris removal. Activities that occur in the field would require a safety orientation and supervision by OMKM natural resources staff or rangers, to ensure safety of volunteers.

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Position	Role	Current Status	Location	Funding Status
Contractors (scientists, environmental consultants, GIS database management)	Implementation of NRMP ⁷	Needed ⁸	Various	Requires funding (project specific)
Rangers	Visitor safety and outreach; natural resources protection	Exists and filled ⁵	VIS	Currently funded
VIS Staff	Visitor outreach and education	Exists and is filled through MKSS ⁵	VIS	Currently funded staff and unfunded volunteers
Education and outreach coordinator	Visitor outreach and education	Position does not yet exist ⁹	OMKM Hilo, VIS	Requires funding
Administrative staff	Administrative duties	Exists and filled ⁵	OMKM Hilo	Currently funded
Librarian	Document retrieval and organization	Exists and filled ⁵	OMKM Hilo	Currently funded
MKSS	Facility support	Exists and filled ⁵	Hale Pōhaku, VIS	Currently funded

5.1.2.2 Training Requirements

Training requirements for all OMKM personnel involved in field-based natural resource management activities includes general safety training, 4-wheel drive vehicle operation, orientation to working at high elevations, CPR and first aid, Global Positioning System (GPS) operation, rules and regulations, and recognition of culturally significant areas and items and protected flora and fauna. Additional training or educational needs for specific personnel are listed below.

Natural Resources Coordinator: Prior to hiring, the NRC should have extensive training in natural resources management issues, preferably in the form of a graduate degree and relevant work experience. On hiring, initial training would include training in project management, education and outreach methods appropriate to Hawai‘i, and familiarization with the plant and animal species found on Mauna Kea, with emphasis on protected species. Other activities to maintain current working knowledge of natural resources management issues would include regular attendance of scientific meetings and conferences, participation in local working groups, and review of relevant scientific journals. Computer training for the NRC should include, if needed, use of statistical packages, Geographic Information System (GIS) software, word processing and database software. Optional training: GIS database management, spatial analysis, and advanced statistics.

Field biologists: Field biologists should have, at minimum, an undergraduate degree in biology or a related field. They should be familiar with field techniques to be used in day-to-day natural resources management activities and should be trained to recognize common Mauna Kea plant and animal species, as well as protected species. Optional training: GIS database management, relevant computer software.

⁷ A range of management actions could be conducted by contractors, including GIS services, baseline inventory, hydrological studies, biological studies, various management actions, or research projects.

⁸ There are currently several natural resource related contracts underway, including studies of the status of the wēkiu bug by Bishop Museum scientists, and a study of wēkiu bug population dynamics, genetics, and natural history by a University of Hawai‘i professor and graduate student. See Section 2.2.2.2 for more information on these studies.

⁹ New position recommended to coordinate non-astronomy related education and outreach activities.

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Volunteers: Safety orientation; natural resources orientation (to be conducted by NRC or a field biologist).

VIS Staff and volunteers: Safety orientation; natural resources orientation (to be conducted by NRC or a field biologist).

5.1.2.3 Facilities and Equipment

Facilities and basic equipment needed to implement the NRMP include

Facilities	Equipment
<ul style="list-style-type: none">• Office space for NRC and field biologist at OMKM, Hilo• Small office space and work area at Hale Pōhaku• Equipment storage area at Hale Pōhaku• Meeting room with audio-visual equipment at OMKM Hilo• Library space for NRMP-related books and documents at OMKM Hilo	<ul style="list-style-type: none">• Computers for NRC and field biologist, with database software, word processing, and GIS software• Color printer• Digital cameras (2 for natural resources staff, 1 for ranger truck)• Walkie-talkies (minimum of 4 sets)• GPS Units (2 for natural resources staff, 1 for ranger truck)• 4-wheel-drive truck• Field equipment (backpacks, measuring tapes, metal stakes, flagging, compasses, field notebooks, binoculars, sample collection materials)• Identification guides (plants, birds, arthropods)

5.1.3 Ongoing Coordination with Other Agencies

Coordination between state and federal agencies regarding management of Mauna Kea's natural resources must be improved. This section describes two programs for coordinating multi-agency management activities on the mountain. The first (Section 5.1.3.1) is an interagency working group to streamline management activities on the mountain and to ensure that management occurs at an ecosystem level. The second (Section 5.1.3.2) is an annual interagency meeting to review and comment on the success of the OMKM NRM Program and the NRMP. Finally, Section 5.1.3.3 describes additional interagency coordination efforts that should be continued or undertaken to ensure the success of the NRM Program.

5.1.3.1 Mountain-wide Natural Resources Management Coordination

The principles of ecosystem management require that neighboring landowners and managers work together, guided by well-established management goals and visions. Overlapping and adjacent jurisdictions at the high elevations of Mauna Kea involve multiple agencies in management and decision-making (see Section 1.4.2). A good example of interagency coordination for land management on the Island of Hawai'i is the Three Mountain Alliance (TMA). It is recommended that the TMA management plan be reviewed and that prior to establishing the Mauna Kea working group, advice be sought from key personnel involved in the formation and operation of the TMA (Three Mountain Alliance 2007).

To increase participation and collaboration between OMKM and state and federal agencies on Mauna Kea, the following actions are recommended

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1. Participate in the development of an interagency working group involving all entities that are responsible for or involved in natural resources management in high elevation areas (above 6,200 ft, or 1,900 m)¹⁰ on Mauna Kea, including OMKM, state and federal agencies, non-governmental organizations (NGOs), private land owners, and other agencies and persons involved in the day-to-day management of Mauna Kea lands.

Table 5-2 lists potential participants in the working group. If such a group already exists when the NRM Program is established, it is recommended that OMKM join it, and the NRC attend meetings.

2. Hold annual working group meetings.
 - a. During the first annual meeting
 - i. Develop an interagency set of mountain-wide management goals based on the principles of ecosystem management. Goals will need to take into account the participants' differing approaches to resource management, their policy foundations, and the decision criteria used by different institutions involved in multi-agency planning processes. Factors that will have to be taken into account include
 1. Department of Land and Natural Resources (DLNR) rules and regulations, including those specific to
 - a. Natural Area Reserve (NAR)¹¹
 - b. Mauna Kea Forest Reserve
 - c. Lands leased to UH¹²
 - d. Conservation District lands
 - e. Conservation District Use Permit regulations and stipulations
 2. Department of Hawaiian Home Lands rules and regulations
 3. Department of Defense, U.S. Army, Pōhakuloa Training Area (PTA) rules and regulations
 4. U.S. Fish and Wildlife Service regulations regarding protected species
 - ii. Clarify management roles on the mountain: Who will carry out what activities and where the funding will come from. Managed activities could include
 1. Ecosystem restoration
 2. Protection and enhancement of protected species (e.g., silversword outplanting)
 3. Hunting
 4. Invasive species management

¹⁰ For simplicity's sake, the working group, at least in the beginning, should focus on the high elevation areas. The cut-off (6,200 ft) was chosen because it is recognized as the boundary above which subalpine vegetation begins on Mauna Kea (Mueller-Dombois and Fosberg 1998). However, the working group may decide to change the area covered once it convenes.

¹¹ OMKM has developed a Cooperative Agreement to address cross-boundary management issues related to the Mauna Kea Ice Age NAR (see Section 1.3.3.1).

¹² As part of the lease agreement, DLNR and UH share responsibility for management in the Mauna Kea Science Reserve (MKSR) and at Hale Pōhaku. See Table VIII-1 in the 2000 Master Plan (Group 70 International 2000) for a detailed matrix showing responsibilities in the high elevation areas of Mauna Kea. These responsibilities may change if UH is able to obtain rule-making authority.

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5. Access
6. Recreation
7. Trail and road maintenance
8. Commercial enterprises (e.g., sightseeing tours)
- iii. Identify opportunities for collaboration, cooperation, and streamlining of natural resource management activities on the mountain.
- iv. Identify gaps in management activities and funding, and collaborate in efforts to fill the gaps.
- v. Identify time frames for various management projects and activities.
- b. At subsequent annual meetings
 - i. Discuss progress towards identified goals.
 - ii. Determine causes of any delays in meeting goals and any problems with implementation.
 - iii. Revise goals, management roles, time frames, and methodology, as needed.
 - iv. Identify new sources of funding, funding gaps, and new potential partners.

Table 5-2. Potential Participants in Mauna Kea Natural Resources Management Working Group

Source	Agency
Federal: Landholders on Mauna Kea ¹³	U.S. Army, Pōhakuloa Training Area (PTA)
Federal: Advisory or Regulatory Agencies	U.S. Fish and Wildlife Service (USFWS) U.S. Geological Survey (USGS) U.S.D.A. Forest Service, Institute of Pacific Islands Forestry (IPIF) U.S.D.A. Natural Resources Conservation Service (NRCS)
State: Landholders/leaseholders	University of Hawai'i (OMKM, IfA) DLNR: Division of Fish and Wildlife (DOFAW) and Natural Area Reserves System (NARS) Department of Hawaiian Home Lands (DHHL)
State: Advisory or Regulatory Agencies	Big Island Invasive Species Committee DLNR: DOFAW BLNR Office of Hawaiian Affairs
NGO	Silversword Alliance The Nature Conservancy Three Mountain Alliance Sierra Club Hawaii Watershed Alliance Hawaii Conservation Alliance
Individuals	Local natural resource experts Private landowners Community members Conservation advocates

¹³ Landholders above 6,200 ft (1,900 m) elevation.

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5.1.3.2 OMKM Natural Resources Management Program Interagency Review

OMKM personnel (including OMKM director, NRC, and members of the MKMB Environment Committee) should meet annually with relevant state and federal agencies to review the status of the OMKM NRM Program. Before the meeting, the NRC should prepare an annual progress report that describes the state of the resources, the status of the management program, progress towards meeting annual goals, and other pertinent information. The report will be reviewed and approved by the MKMB Environmental Committee and OMKM and will then be submitted to the stakeholders and agencies participating in the review process, allowing ample time before the meeting for the agencies to review it. The annual meeting will provide a mechanism for various agencies to review the OMKM NRM Program, provide feedback on management activities, and suggest additional activities or changes to the management program. Agencies to involve include USFWS, DLNR, and any other state or federal agencies participating in management activities or agreements with OMKM. The annual progress report is discussed further in Section 5.2.

5.1.3.3 Other Interagency Efforts

Other interagency efforts that will increase the success of the NRM Program include

1. Continue participation of the Big Island NARS manager on the MKMB Environment Committee.
2. Ensure diverse representation on the MKMB Environmental Committee, including local scientific experts, conservation advocates, and land managers and agencies.
3. Establish working relations with environmental staff at PTA, to cooperate and coordinate on natural resources management projects.

5.1.4 Budgets and Funding

Start-up costs for the NRM Program include furnishing office space and storage areas and for purchasing basic equipment (see Section 5.1.2.3). Annual operational expenses for the NRM Program will include salary and benefits for the NRC and field biologist(s), maintenance of equipment and vehicles, expenditures for various contracts¹⁴ (initial baseline inventory, specialized annual monitoring¹⁵, GIS database management). Annual operational expenses should also include a travel allowance for the NRC to attend public meetings on-island and interisland, the Hawai'i Conservation Conference, and one other relevant conference annually. Although many of the management actions can be implemented by operational funds to support staff, project-specific funds may be required for one-time projects or projects that require large amounts of funding, such as baseline inventories, mitigation or large-scale restoration projects, and multi-agency projects.

Potential sources of funds for start-up and annual operation costs include

- Increase in base funding provided to OMKM by the University of Hawai'i
- OMKM Revolving Fund, which is supported in part by fees collected from commercial tour operators

¹⁴ If not done in-house.

¹⁵ Specialized annual monitoring is monitoring that requires in-depth knowledge that the NRM may not possess, such as identification of certain organisms or plants.

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- Funds provided by existing observatories as good-will efforts, to aid natural resources management of the summit and Hale Pōhaku
- Funds provided through lease agreements for potential new astronomy development to support natural resources management activities
- User fees and licenses: vehicle entry fees (if implemented); license fees from commercial tour operations; fees for rental or use of facilities at Hale Pōhaku for non-astronomy activities, events, and research
- Revenue collected from enforcement of rules (if implemented)

Potential sources of project-specific funding include

- OMKM base-funding requests
- Cost-sharing through agency partnering
- Using volunteer labor when possible
- Funds provided by new projects and existing observatories as part of environmental analysis or mitigation of environmental damage
- Research and management grants provided by federal and state agencies

5.1.5 Schedule

Implementation of the NRMP will begin with the acceptance of the NRMP by the MKMB and BLNR (as part of the Mauna Kea Comprehensive Management Plan [CMP]). The development of the NRM Program would begin once the NRMP is accepted and funding sources are identified.¹⁶ The following schedule begins once funding is secured for the NRM Program, including funding for baseline inventories.

Year 1

1. Obtain office space and equipment needed for NRM Program (see Section 5.1.2.3).
2. Advertise and fill NRC and field biologist positions (see Sections 5.1.2.1 and 5.1.2.2).
3. Request proposals for baseline inventories (plants, invertebrates, birds and mammals, hydrological and geological resources) and hire contractors.
4. Begin development of NRM Program.
 - a. Begin developing component programs as described in the Section 4 component plans
 - b. Begin education and outreach activities
5. Draft RFPs and determine funding sources for projects that cannot be completed in house.

Year 2

1. Complete baseline inventories and associated data analysis.
 - a. Using data obtained from baseline inventories, designate high-priority management areas (e.g., areas with high ecological value, sensitive areas, critical habitat or rare species habitat,

¹⁶ OMKM may need to secure increases in base funding or obtain funds from other sources. If funding is limited, this NRMP may be implemented incrementally.

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and areas with significant ecological damage or problems). These areas will be the main focus of management activities.

2. Determine high-priority management actions for each of the component plans, using information obtained from baseline inventories.
3. Continue developing in-house programs, such as education and outreach activities, invasive species prevention and control.
4. Establish volunteer groups and conduct volunteer-based resource management activities.

Year 3

1. Review, evaluate, and revise NRMP as needed, to reflect findings from baseline inventories.
2. Establish priorities for management actions and develop a long-term timeline for natural resources management projects.
3. Begin annual monitoring (see Section 4.1).
4. Continue and improve upon component programs.

Year 4

1. Review, evaluate, and revise NRM Program as needed, based on Year 3.
2. Continue and improve upon component programs.

Year 5

1. Continue and improve upon component programs.
2. Review and evaluate NRM Program, in-depth.
3. Prepare stakeholder report on the status of Mauna Kea's natural resources, and the progress of the NRM Program.

Year 6

1. Continue and improve upon component programs.
2. Hold NRMP review meetings (see Section 5.2.2.2).
3. Revise NRMP, reprioritize NRM Program actions for following five-year interval.

5.2 Evaluation Plan

To ensure the best possible protection for Mauna Kea's high-elevation resources, the success of management actions to protect and conserve those resources must be regularly evaluated. This section describes methods that can be used to ensure that management actions are achieving stated NRMP goals and objectives in UH Management Areas. Section 5.2.1 describes how the NRC and OMKM will monitor progress towards meeting natural resources management goals. Section 5.2.2 describes the NRMP review and revision process.

5.2.1 Monitoring NRMP Implementation

Regular monitoring of NRMP implementation must occur in order to determine if progress is being made towards meeting the goals and objectives of the NRMP. The NRM Program will be monitored annually,

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with annual progress reports issued as described in Section 5.2.2.1. A major review and revision of the NRMP will occur every five years, as described in Section 5.2.2.2.

Monitoring of a natural resources management program requires collection of concrete data that can be objectively analyzed and compared between years. This requires preparation at the beginning of each year, to determine the performance measures by which the year will be judged, followed by collection of data throughout the year on progress made toward meeting these measures. Preferably, the NRC will conduct brief monthly progress checks, to ensure that management activities are begun at appropriate times, that nothing is forgotten, and that projects are progressing as scheduled. Good notes taken throughout the year on the causes of delays or concerning unrealistic scheduling will enable the NRC to more thoughtfully analyze annual progress and determine course-corrections for the following year. The annual monitoring program should occur as follows:

1. At the beginning of each year, the NRC will establish a list of priority management actions to occur that year, along with a realistic schedule. These actions should be based on the components developed in the NRMP, along with any new pressing issues that may have come to light since the last update of the NRMP.
 - a. The NRC should take care that the schedule is realistic and that there are not more tasks than can be completed in the number of man-hours available in the year. If it is consistently found that there are more tasks that must be completed than there are man-hours to complete them, staffing needs should be reviewed and new staff added, as needed.
 - b. Management actions and projects that require a great deal of field labor (e.g., invasive weed control on a large scale), or expertise that the NRC and field biologist(s) do not have (e.g., invertebrate surveys if the NRC or field biologist is not an entomologist) should be contracted out, to ensure that they are conducted on schedule.
2. When the list of priority management actions and the schedule is completed, the NRC should create a progress tracking datasheet, using the listed actions, and begin tracking progress towards meeting the actions.
 - a. It is useful to break up larger actions into smaller components that can be individually tracked and checked off when complete. This will give a sense of progress for some of the larger items that may be complete only at the end of the year, or even after several years. Ongoing projects should be broken into monthly components, or as appropriate.
 - b. As each action is completed, the NRC should enter the date of completion into the datasheet. It is easy to forget when projects were completed if you are attempting to recall this information at the end of a busy year.
 - c. Notes on problems encountered during management actions, interesting outcomes, successes, and ideas for improving management actions in the future should be kept on a linked document, to allow for easy cross-reference. This will help when writing the progress report at the end of the year.
 - d. The progress tracking datasheets and schedule should be referenced at the beginning of each month, and updated as appropriate.
3. At the end of each year, the NRC should review the progress of that year's management-program activities by reviewing the progress-tracking datasheet. This datasheet will provide information on the percentage of management actions completed during the year and can reveal patterns in the strengths and weaknesses in the management program. The notes will provide helpful information on how best to improve the management actions, if they are to be continued the next

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year. Comparison of the projected schedule with the actual schedule will enable the NRC to better estimate timelines for future projects and will help determine if the scale and scope of the actions slated for the following year(s) are appropriate for the staffing level.

4. After the progress tracking forms are analyzed, the NRC should produce an annual report, as described in Section 5.2.2.1.

5.2.2 Review and Revision

The principles of adaptive management require regular review of the program and revision of management goals, objectives, actions, and techniques, to improve the performance of the program. Two review processes, an annual progress report and a five-year management outcome assessment, are recommended to assess the success of the NRM Program and to enable revision of the NRMP.

5.2.2.1 Annual Progress Report

At the end of each year the NRC should produce an annual progress report describing in detail the management goals, objectives, and actions for the year and what progress was made towards meeting them. The report should also describe actions to be taken to improve the program for the next year(s). This report is not intended to be a status report on the natural resources in UH Management Areas,¹⁷ rather it is meant to inform management and stakeholders of the progress of the program and direction it is to take in the future.

This progress report should be presented at an annual meeting, to be held before the following year's management priorities and schedule are set. This will allow for input into the NRM Program by OMKM, MKMB, the MKMB Environment Committee, DLNR, and other agencies, as deemed appropriate (see Section 5.1.3.2).

5.2.2.2 Five-Year Management Outcome Analysis and NRMP Revision

The NRM Program should be subjected to a major review every five years, and the NRMP should be revised, as necessary. This process should involve input from state and federal agencies and the public.

5.2.2.2.1 Management Outcome Analysis

Determination of the outcome of management activities on the natural resources and of the success of the management program will be accomplished through a report summarizing the state of natural resources on Mauna Kea and the progress of the NRM Program over the preceding five years.

The first section of the report will discuss the state of the natural resources in UH Management Areas. This section will summarize data collected during monitoring, research, restoration, and threat prevention and control activities conducted over the preceding five years (See Section 4).¹⁸ This portion of the report will analyze trends in natural resources, and the impacts (positive, negative, or neutral) that management actions have had on them. It will also summarize what future management actions are needed to protect, enhance, or restore Mauna Kea's natural resources.

¹⁷ The status of natural resources in UH Management Areas will be tracked during annual natural resources monitoring and will be presented in the annual Natural Resources Monitoring Report. See Section 4.1 for information on natural resources monitoring.

¹⁸ The source of the data will be the annual reports produced as part of the various component plans.

Section 5. Implementation and Evaluation Plan

The second section of the Five-Year Management Outcome Analysis should include a summary of the progress of the NRM Program towards meeting management goals, objectives, and actions, as outlined in the NRMP and in the annual listing of priority management actions (see 5.2.1). The source of information for this section of the report will be the annual progress reports from the last five years. Additionally, the NRC should review the NRMP and determine if any goals or objectives were not addressed during the preceding five years, and if so, why not. This section will discuss strengths and weaknesses of the NRMP and the NRM Program and ways to improve them.

The purpose of the Management Outcome Analysis is to provide analysis of both the condition of the natural resources in UH Management Areas and the status of the NRM Program and Plan. This information will be used to update the NRMP, so that it better addresses the needs of the natural resources, and to improve management activities through adaptive management.

A draft of this report should be submitted for review and comment to OMKM, MKMB, the MKMB Environment Committee, and state and federal agencies, as deemed necessary or appropriate. This will provide a mechanism for the interested parties to provide input into the direction the NRM Program and suggestions for changes to the NRMP. A final version of the report can then be presented to the public for comments and suggestions to be used in revising the NRMP.

5.2.2.2 Revising the Natural Resources Management Plan

Following the production of the Five-Year Management Outcome Analysis, and after input from appropriate stakeholders, the NRMP should be revised and updated to incorporate new management goals, objectives, and actions. This major review and revision process should occur on the sixth year (to allow for time to process the five-year review). If it is determined that the five-year cycle is too short to show real changes in resource conditions, then after two five-year review and revision cycles, the frequency of the process can be lengthened, as needed.

It should be noted that as of the first draft of this NRMP, no quantitative baseline inventories of the natural resources on UH Management Areas have been conducted. Therefore, the true state of the natural resources is currently unknown, and completion of the baseline inventories will necessitate a re-evaluation of the management actions recommended in the component plans in Section 4. It may be necessary to complete one or more in-house reviews and revisions of the NRMP and management priorities during the first several years of the program, to determine impediments to successful management of natural resources, develop realistic timelines for projects, and make necessary changes to the structure of the program. This can be done on an as-needed basis, to be determined by the NRC, OMKM director, and MKMB Environment Committee.

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8 Glossary

Aa: Common type of basalt lava with rough broken surface; from Hawaiian word ‘a‘ā.

Adaptive management: Systematic process for continually improving management policies and practices by learning from the outcomes of past and current management activities. Adaptive management recognizes that there is a level of uncertainty about the “best” policy or practice for a particular management issue, and therefore requires that each management decision be revisited in the future to determine if it is providing the desired outcome.

Aeolian: Process pertaining to the wind in which particles are detached, transported and deposited. On Mauna Kea the aeolian processes are integral to at least one endemic arthropod due to the import of food resources transported from lower slopes of Mauna Kea to its highest elevations.

Albedo: Ratio of the amount of sunlight that is reflected and absorbed by a surface; 1.0 is a completely reflective surface.

Alien: When used in reference to a plant or animal species, alien means that the species was introduced (accidentally or on purpose) by mankind, and does not naturally occur in the location.

Alkalic: Igneous rock chemical classification based on total alkali ($\text{Na}_2\text{O} + \text{K}_2\text{O}$) vs. silica (SiO_2) content; alkalic rocks have greater total alkali than tholeiitic rocks at the same silica content.

Alpine: Living or growing on mountains above the timberline. On Mauna Kea alpine ecosystems occur above the nocturnal ground frost line, which is found at 9,800 ft (3,000 m).

Alteration: Change in character, appearance, direction, or status.

Anthropogenic: Relating to or resulting from the influence humans have on the natural world.

Aquifer: Water bearing geological layer. Aquifers are often used to provide water for human needs.

Arthropods: Organisms with jointed appendages and exoskeletons, including insects, spiders, and crustaceans.

Baseline inventory: Initial survey establishing the status of natural resources (population sizes, distributions, and biological diversity). Conducted at the beginning of a natural resources management program.

Bedload: Particles of sand, gravel, or soil moved by water along the bottom of a stream, gulch or river.

Biodiversity: Full range of natural variety and variability within and among living organisms, and the ecological and environmental complexes in which they occur.

Candidate species: Species that is possibly declining in population and that is being considered for threatened or endangered status under the Endangered Species Act.

Cesspool: Underground reservoir for liquid waste.

Cinder: Fragment of cooled pyroclastic lava material, typically very porous and with low particle density, making them light for their size. Also called tephra and scoria.

Cinder cone: Conical hill formed by the accumulation of volcanic ash or cinder around a vent.

Climate: Long term average of meteorological variables representative of the geographic area where the variables have been collected.

Community: In ecology, a community is an assemblage of populations of different species, interacting with one another.

Control: When used in reference to invasive species, control is the long-term reduction of invasive species density and abundance to an acceptable threshold.

Decommission: To remove from service.

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- Dike:** Mass of intrusive igneous rock that has been injected into a fissure while molten, usually vertically aligned to the ground surface.
- Dormant:** Marked by a suspension of activity; temporarily devoid of identifiable activity.
- Ecosystem:** Dynamic system of living organisms (plants, animals, and microorganisms) within an area, the environment sustaining them, and their interactions. An ecosystem can range in size from a tiny site containing only a few species, such as an isolated lake, to a huge area containing thousands of species, such as a tropical rainforest.
- Ecosystem health:** Condition of an ecosystem in which its dynamic attributes are expressed within the range of activity normal for its stage of development.
- Ecosystem integrity:** Achieved when an ecosystem has the biodiversity characteristics of a reference ecosystem such as species composition and community structure, and is fully capable of sustaining normal ecosystem functioning.
- Ecosystem restoration:** The process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed.
- Endemic:** Native to, and restricted to, a particular geographical region. Highly endemic species are those with very restricted natural ranges; they are especially vulnerable to extinction if their natural habitat is eliminated or significantly disturbed.
- Ephemeral:** Description of stream or gulch hydrology in which surface water flow occurs only following periods of rainfall or snow melt.
- Eradicate:** To completely remove or destroy the entire population. When used in reference to invasive species, it refers to removal of the invasive species from an entire landmass, such as the entire Island of Hawai'i. Eradication is extremely rare in the case of invasive species, and generally occurs only on very small islands and in isolated locations, or with very small populations.
- Erodibility:** Potential of soil to be eroded or physically altered by the action of water or wind.
- Erosion hazard:** Rating or classification of the potential of a surface to erode; used to identify areas to avoid developing or take special precautions.
- Erosivity:** Potential of water and wind to detach and transport soil or rock.
- Evapotranspiration:** Loss of water from the combined effects of evaporation and transpiration from plants.
- Evaporation:** Phase change of water from liquid to vapor; classified as a loss in the hydrologic cycle.
- Exclosure:** Limited area from which animals such as sheep, pigs, or cattle are excluded by fencing. Fencing, and subsequent removal of non-native mammals, is a habitat management technique used in areas containing native plants or animals that are susceptible to grazing or predation by non-native mammals.
- Exotic:** Introduced from another part of the world; not native to the place where found.
- Fauna:** Animals or animal life of a region or environment.
- Fissure:** Narrow opening or crack of considerable length and depth, usually occurring from some breaking or forced parting.
- Flora:** Plants or plant life of a region or environment.
- Geographic Information System (GIS):** Computer software used to store, view, and analyze geospatial information. Outputs include analysis, maps and images.
- Glacial member:** Layers of glacial deposit used to describe the three glacial episodes that occurred on Mauna Kea.
- Gully:** Trench originally worn in the earth by running water and through which water often runs after rain.

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Headcut: Location where a sudden change in ground elevation occurs, usually at the leading edge of a gully. Headcuts often result in rapid erosion and incision of the runoff channel.

Hydraulic conductivity: Quantification of the transmission rate of a liquid. Movement of water through soil or rock is a function of the materials conductivity.

Incidental take: Unknown or accidental killing or removing of an organism.

Incipient invasive species: Invasive species that has not yet become established. For this plan, refers to known invasive species found in Hawai‘i that are not currently on UH Management Areas but that are thought to pose a threat to subalpine or alpine communities.

Indigenous: Native to a given region or ecosystem. An indigenous species differs from an endemic species in that it may occur in several locations in the world, while an endemic species is limited to one area or region.

Interstitial pores: Openings or voids contained in a soil or rock.

Invasive species: Non-native (alien) species whose introduction does or is likely to cause economic or environmental harm or harm to human health.

Introduced: When used in reference to a plant or animal species, the term means that the species was brought to a new location by man (either purposefully or accidentally).

In-situ: In the natural or original position or place.

Isotopic analysis: The analysis of the isotope composition of a sample.

Leachate: Solution or product that gradually moves through a matrix to a new location.

Leach field: The soil surrounding and immediately down gradient of a septic tank used to absorb leached septic liquids.

Lichen: Symbiotic associations of a fungus with a photosynthetic partner (either green alga or cyanobacterium) that can produce food for the lichen from sunlight. Usually found growing on rocks or trees.

Lithology: Character of a rock or rock formation as described by its components.

MKSR: Mauna Kea Science Reserve. An 11,288 ac (4,568 ha) parcel of state land above 11,500 ft (3,505 m) elevation on Mauna Kea, leased by the University of Hawai‘i.

Mauna Kea Forest Reserve: Approximately 448,000 acre forest reserve and part of the State of Hawai‘i Forest Reserve System. Circles Mauna Kea, and is found directly below the MKSR.

Metadata: Data that provides descriptive information about other data.

Mitigation: Elimination, reduction or control of the adverse environmental effects of a project. Mitigation includes restitution for any damage to the environment caused by such effects through replacement, restoration, compensation or any other means.

Monitoring: Recording changes to an entity over time in order to understand how actions, activities and ecosystem processes affect it. Monitoring is conducted as part of a plan to evaluate management prescriptions.

Natural Area Reserve (NAR): Part of DLNR, the reserves are created to preserve and protect representative samples of Hawaiian biological ecosystems and geological formations. The Ice Age Natural Area Reserve is located on Mauna Kea.

Native: Naturally occurring in a given area. When used in reference to plants and animals in Hawai‘i, the term native means species that were not brought to the islands by mankind.

NRCS soil survey: Scientific document describing the physical and chemical attributes of soil.

Nunatak: Areas of cinder cones that remained ice-free by being above the surrounding glacier during the previous glaciation period.

Orographic: Associated with or induced by the presence of mountains, e.g., cloud lift and development.

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Outcrop: To project from the surrounding soil.

Outplanting: Planting of greenhouse or pot-grown plants into an area.

Paleosol: Soil horizon from the geologic past; usually buried beneath other rocks or recent soil horizons.

Percolate: Movement of liquid through a permeable substance.

Permafrost: Layer of ice usually located beneath the ground surface, which is maintained year round.

Pu'u: Hawaiian name for hill. With respect to Mauna Kea, pu'u refers to the volcanic cinder cones found at the summit.

Rare: Occurring at low densities, or in limited locations.

Rehabilitation: Repair of habitat following a disturbance. Rehabilitation emphasizes the repair of ecosystem processes, productivity, and services, rather than reestablishment of historical plant and animal communities (which is the focus of restoration).

Relic: Something that has survived the passage of time.

Restoration: The actions or activities implemented in order to return damaged or altered habitat or a component of the ecosystem to a historical condition, including physical habitat attributes as well as community composition and native species abundance.

Rill: Small erosion feature created by water flow. With time rills can either join together to form a gully or expand into a gully.

Ruderal: Plants that colonize disturbed sites, bare soil, or waste piles.

Seep: Spot where water trickles out of the ground.

Segetal: Plants that grow inter-mixed with crop species.

Sensitive area: Area that is deemed in need of protection. Sensitive areas may include areas with a rare, Threatened, or Endangered species; a unique native community; or physical resources. Sensitive areas may also be areas prone to disturbance such as erosion or crushing of cinder.

Septic tank: Tank used in the collection of human waste and gray water in which solid materials settle to the bottom and liquid waste is discharged onto a leach field (an area lined with highly porous materials allowing effluent to seep into the ground).

Site recycling: Reuse of a previously developed site. In the case of the observatories, refers to removal of an old observatory and replacement with a new one.

Snowpack: Accumulation of naturally formed, packed snow over an area that usually melts during the warmer months.

Species of Concern: Those species that might be in need of conservation action, but that are not currently Listed or Candidate species. Species of Concern receive no legal protection and use of the term does not necessarily imply that a species will eventually be proposed for listing.

Spring: Ground water discharging out of the earth where the water table meets the ground surface.

Stratigraphy: Geology discipline dealing with the origin, composition, distribution, and succession of strata (layers of sedimentary rock); the arrangement of strata.

Subalpine: Of, relating to, or inhabiting high upland slopes and especially the zone just below the timberline. On Mauna Kea, the subalpine region occurs from approximately 5,600 ft to 9,800 ft (1,700 m to 3,000 m) elevation.

Sublimation: Process by which water in its solid phase is transformed directly to vapor phase without first passing through the liquid phase. Sublimation rates are highest in areas where relative humidity is low, dry winds are present, and at high elevations where atmospheric pressure is low and sunlight is strong.

Subsidence: To sink; to tend downward. Refers to the slow process of volcanic island sinking due to the continued accumulation of extruded material and associated weight.

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Tephra: Fragments of volcanic rock and lava regardless of size that are blasted into the air by explosions or carried upward by hot gases in eruption columns or lava fountains. Tephra includes large dense blocks and bombs, and small light rock debris that have usually solidified prior to hitting the ground.

Tholeiitic: Igneous rock chemical classification based on total alkali ($\text{Na}_2\text{O} + \text{K}_2\text{O}$) vs. silica (SiO_2) content; tholeiitic rocks have less total alkali than alkalic rocks at the same silica content.

Threatened and Endangered Species: Plant or animal that is in danger of extinction throughout all, or a significant portion, of its range. Federally listed threatened and endangered species are those species that the US Fish and Wildlife Service has determined require federal action to protect them. Protection of Federally listed threatened and endangered species is mandated by the United States Endangered Species Act, 1973.

Ungulate: Hoofed, typically herbivorous, quadruped mammal.

Upwelling: Process or an instance of rising or appearing to rise to the surface.

Vascular plant: Plant with water and fluid conductive tissue (xylem and phloem); includes seed plants, ferns, and fern allies. Does not include fungus, lichens or mosses.

Weathering: Physical disintegration and chemical decomposition of earth materials at or near the earth's surface.

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